WHAT IS CLAIMED IS:

1. A color separation method for determining quantities of a plurality of color inks in order to reproduce a arbitrary color with the plurality of color inks on a printing medium, the method comprising the steps of:

(a) defining an ink set that includes as useable inks a plurality of chromatic primary color inks that when used in combination can reproduce achromatic color, and at least one spot color ink of hue different from any of the plurality of chromatic primary color inks;

(b) determining a plurality of reproduction colors to be reproduced on a print medium according to a plurality of input colors within a chromatic primary color space, a term "reproduction color" denoting a color to be reproduced on the print medium according to any one input color, a term "color separation ink quantity set" denoting a combination of ink quantities of the ink set for reproducing a reproduction color on the print medium, a term "chromatic primary color space" denoting a color space having base vectors representing ink quantities of the plurality of chromatic primary color inks; and

(c) determining a plurality of color separation ink quantity sets for reproducing the plurality of reproduction colors,

wherein the step (c) including, for each reproduction color, the steps of:

(c1) calculating a lightness parameter value correlated to lightness of the reproduction color; and

(c2) adjusting an ink quantity of the spot color ink in the color separation ink quantity set in accordance with the lightness parameter value, so as to reduce the ink quantity at a rate of change greater than a rate of change of the lightness parameter value when the lightness parameter changes in a lighter direction.

2. A color separation method according to Claim 1, wherein the step (c2) includes adjusting the ink quantity of the spot color ink such that decrease of the spot color ink quantity with respect to change of the lightness parameter

value exceeds decrease of the chromatic primary color ink quantities with respect to the change of the lightness parameter value.

3. A color separation method according to Claim 1, wherein the step (c2) includes adjusting the spot color ink quantity so as to decrease at a greater rate than a rate proportional to the lightness parameter value.

4. A color separation method according to Claim 1, wherein the step (c2) includes adjusting the spot color ink quantity such that actual ink quantity of the spot color ink is smaller than a hypothetical ink quantity of the spot color ink when the lightness parameter value is in a predetermined brightest range, the hypothetical ink quantity being defined to be ink quantity of a spot color ink included in the color separation ink quantity set for reproducing the reproduction color and being obtainable by adjusting ink quantity of each ink in the color separation ink quantity set so as to minimize a sum of ink quantities.

5. A color separation method according to Claim 1, wherein the step (c2) includes adjusting the spot color ink quantity such that a proportion of actual ink quantity of the spot color ink to a hypothetical ink quantity of the spot color ink decreases monotonically with respect to change of the lightness parameter value in the lighter direction, the hypothetical ink quantity being defined to be ink quantity of a spot color ink included in the color separation ink quantity set for reproducing the reproduction color and being obtainable by adjusting ink quantity of each ink in the color separation ink quantity set so as to minimize a sum of ink quantities.

6. A color separation method according to Claim 1, wherein the step (c2) includes adjusting the spot color ink quantity such that the ink quantity of the spot color ink is set zero in a first range which is a brightest part of an entire range of the lightness parameter value.

7. A color separation method according to Claim 1, wherein the lightness parameter value is a maximum value assumable by ink quantity of the spot color ink when reproducing the reproduction color.

8. A color separation method according to Claim 1, wherein the step (c2) comprises the steps of:

(c2-1) calculating a temporary ink quantity of the spot color ink from the lightness parameter value;

(c2-2) determining temporary ink quantities for the chromatic primary color inks which in conjunction with the temporary ink quantity of the spot color ink are needed to reproduce the reproduction color, thereby obtaining a temporary ink quantity set; and

(c2-3) adopting the temporary ink quantity set per se as the color separation ink quantity set when the temporary ink quantity set is within ink duty limits which limit an upper value of ink quantity useable per unit of area of the print medium, and when the temporary ink quantity set exceeds the ink duty limits, correcting the temporary ink quantity set so as to meet the ink duty limits to determine the color separation ink quantity set.

9. A color separation method according to Claim 8, wherein the ink set includes first and second spot color inks,

the step (c1) includes calculating the lightness parameter value for each of the first and second spot color inks independently,

the step (c2-1) includes determining temporary ink quantities of the first and second spot color inks based on the lightness parameter value for each of the first and second spot color inks, and

the step (c2-3) includes, when the temporary ink quantity set exceeds the ink duty limits, determining the color separation ink quantity set such that, within a two-dimensional color space defined by ink quantities of the first and second spot color inks, a color coordinate point defined by color separation ink quantities of the first and second spot color inks is present inside a range that meets the ink duty limits and situated in proximity to another color

coordinate point defined by the temporary ink quantities of the first and second spot color inks.

10. A color separation method according to Claim 9, wherein the step (c2-3) includes, when the temporary ink quantity set exceeds the ink duty limits, determining the color separation ink quantity set such that, within the two-dimensional color space relating to ink quantities of the first and second spot color inks, a color coordinate point defined by color separation ink quantities of the first and second spot color inks is present inside a range that meets the ink duty limits, and such that a ratio of the color separation ink quantities of the first and second spot color inks is equal to a ratio of the temporary ink quantities of the first and second spot color inks.

11. A color separation method according to Claim 1, wherein the ink set includes a plurality of the spot color inks, and

the step (c2) includes performing adjustment of each ink quantity of the spot color inks by means of limiting a value assumable by a specific spot color ink parameter to a smaller range in association with higher lightness indicated by the lightness parameter value, the spot color ink parameter having characteristic of increasing in association with greater ink quantities of a spot color ink included in the color separation ink quantity set.

12. A color separation method according to Claim 1, wherein the spot color ink contains colorant different from colorants of the plurality of chromatic primary color inks.

13. A color separation method according to Claim 1, wherein the spot color ink is able to reproduce higher saturation than a mixture of the chromatic primary color inks when a hue reproducible by the spot color ink is reproduced by the mixture of the plurality of chromatic primary color inks.

14. A color separation method according to Claim 1, wherein the step (b) comprises the steps of:

(b1) determining an outermost shell color separation ink quantity set associated with outermost shell chromatic color, where the outermost shell chromatic color refers to chromatic color at an outermost shell location within the primary color space, the outermost shell color separation ink quantity set being used for reproducing extended chromatic color that is reproducible with the ink set and that has higher saturation than the outermost shell chromatic color; and

(b2) determining the plurality of reproduction colors associated respectively with the plurality of input colors within the primary color space, based on relationship between the outermost shell chromatic color and the outermost shell color separation ink quantity set;

wherein the step (b1) includes the steps of:

establishing an upper limit of useable ink quantity per unit of area of the print medium as an ink duty limit; and

determining the extended chromatic color as a color represented by an extended chromatic color vector of greater length having a same direction as an outermost shell chromatic color vector representing the outermost shell chromatic color in the primary color space, and determining the outermost shell color separation ink quantity set for reproducing the extended chromatic color;

and wherein determination of the extended chromatic color and the outermost shell color separation ink quantity set is performed so as to meet the following condition:

(i) the outermost shell color separation ink quantity set is within the ink duty limit.

15. A color separation method according to Claim 14, wherein determination of the extended chromatic color and the outermost shell color separation ink quantity set is performed so as to additionally meet the following condition:

(ii) length of the extended chromatic color vector is the greatest length within a range reproducible by the ink set.

16. A color separation method according to Claim 14, wherein determination of the extended chromatic color and the outermost shell color separation ink quantity set is performed so as to additionally meet the following condition:

(iii) total ink quantity of the outermost shell color separation ink quantity set for reproducing the extended chromatic color is the smallest possible.

17. A color separation method according to Claim 14, wherein the reproduction color is a color reproduced by a provisional color separation ink quantity set derived by multiplying the outermost shell color separation ink quantity set for the outermost shell chromatic color having a same vector as the input color in the primary color space, by a ratio of a length of the input color vector to a length of the outermost shell chromatic color vector.

18. A color separation method according to Claim 1, wherein the ink set includes two first and second spot color inks of mutually different hues,

wherein a term "substitution quantities" for a particular spot color ink denotes ink quantities of the plurality of chromatic primary color inks used for reproducing hue and saturation substantially identical to the particular spot color ink by means of substituting a particular quantity of the particular spot color ink with a combination of the plurality of chromatic primary color inks,

wherein a term "principal component primary color inks" for each of the first and second spot color inks denotes two inks with largest substitution quantities,

and wherein one of the two principal component primary color inks for the first spot color ink and one of the two principal component primary color inks for the second spot color ink are different inks.

19. A color separation method according to Claim 1, wherein the ink set includes black ink, and

the step (b) comprises the step of calculating a corrected input color composed of a plurality of chromatic primary color components which are decreased so as to produce a black component by means of an under color removal process for the black ink on the input color,

and wherein the reproduction color is determined according to the corrected input color.

20. A method for creating a color conversion lookup table for converting input color image data expressed in a first color system into second color image data expressed in a reproduction color system,

wherein the reproduction color system is a color system for reproducing color using an ink set that includes a plurality of chromatic primary color inks that used in combination can reproduce achromatic color, and at least one spot color ink of hue different from any of the plurality of chromatic primary color inks;

wherein the method for creating a color conversion lookup table comprises the steps of:

establishing a first correspondence relationship for converting a first tone value set expressed in the first color system to a primary color tone value set expressed in a primary color system for ink quantities of the plurality of chromatic primary color inks;

establishing a second correspondence relationship for converting a primary color tone value set for each of a plurality of input colors within the primary color system into ink quantities of the ink set in accordance with the color separation method of Claim 1; and

calculating, based on the first and second correspondence relationships, correspondence relationships between the first tone value set expressed in the first color system and ink quantities of the ink set, and storing the relationships in the color conversion lookup table.

21. An image data processing apparatus for converting input color image data expressed in a first color system to second color image data expressed in a reproduction color system, the apparatus comprising:

a color conversion lookup table created according to the method of Claim 20; and

a color conversion module for executing the converting while making reference to the color conversion lookup table.

22. A color separation method for determining ink quantities of a plurality of color inks in order to reproduce an arbitrary color with the plurality of color inks on a printing medium, the method comprising the steps of:

(a) defining an ink set that includes as useable inks a plurality of chromatic primary color inks that when used in combination can reproduce achromatic color, and at least one spot color ink of hue different from any of the plurality of chromatic primary color inks;

(b) determining a plurality of reproduction colors to be reproduced on a print medium according to a plurality of input colors within a chromatic primary color space, a term "reproduction color" denoting a color to be reproduced on the print medium according to any one input color, a term "color separation ink quantity set" denoting a combination of ink quantities of the ink set for reproducing a reproduction color on the print medium, a term "chromatic primary color space" denoting a color space having base vectors representing ink quantities of the plurality of chromatic primary color inks; and

(c) determining a plurality of color separation ink quantity sets for reproducing the plurality of reproduction colors,

wherein a proportion of actual ink quantity of the spot color ink to a maximum ink quantity of the spot color ink determined according to the reproduction color is termed "spot color ink usage rate",

and when hue of the reproduction color is reproduced by means of a combination of a single chromatic primary color ink and a single spot color ink, the single chromatic primary color ink is termed "primary color component ink", and the single spot color ink is termed "spot color component ink",

the step (c) includes executing, for each reproduction color, the steps of:

(c1) calculating a lightness parameter value correlated to lightness of the reproduction color; and

(c2) providing first and second reproduction colors, the first and second reproduction colors having a lightness parameter value within a first high lightness range including a brightest portion of the lightness parameter value, the first and second reproduction colors having a same primary color component ink, a same spot color component ink, and a same lightness parameter value, the first reproduction color having hue relatively close to that of the primary color component ink, the second reproduction color having hue relatively close to that of the spot color component ink; and determining ink quantity of the spot color ink included in the color separation ink quantity set so that a usage rate of the spot color ink for the second reproduction color is smaller than a usage rate of the spot color ink for the first reproduction color.

23. A color separation method according to Claim 22, wherein the predetermined maximum ink quantity of the spot color ink is ink quantity when the spot color ink is used as much as possible within a range in which the reproduction color is reproducible.

24. A color separation method according to Claim 22, wherein

when the plurality of chromatic primary color inks include cyan ink, magenta ink, and yellow ink,

the step (c2) includes:

when the primary color component ink common to the first and second reproduction colors is cyan ink or magenta ink, determining the ink quantity of the spot color ink included in the color separation ink quantity set

such that the usage rate of the spot color ink for the second reproduction color is smaller than the usage rate of the spot color ink for the first reproduction color.

25. A color separation method according to Claim 22, wherein the step (c2) includes determining ink quantity of the spot color ink in the color separation ink quantity set such that ink quantity of the spot color ink decreases at a rate of change greater than a rate of change of the lightness parameter value when the lightness parameter changes in a lighter direction.

26. A color separation method according to Claim 22, wherein the step (c2) includes adjusting ink quantity of the spot color ink in the color separation ink quantity set such that ink quantity of the spot color ink decreases at a rate of change greater than a rate of change of the chromatic primary color ink, according to change of the lightness parameter value.

27. A color separation method according to Claim 22, wherein the step (c2) includes adjusting ink quantity of the spot color ink quantity so as to decrease to a greater extent than decrease proportional to the lightness parameter value.

28. A color separation method according to Claim 22, wherein the step (c2) includes, when the lightness parameter value is in a brightest portion of the lightness parameter value, adjusting actual ink quantity of the spot color ink included in the color separation ink quantity set for reproducing the reproduction color to be smaller than a hypothetical color separation ink quantity of the spot color ink, the hypothetical ink quantity of the spot color ink being obtainable by adjusting ink quantity of each ink so as to minimize a sum of ink quantities.

29. A color separation method according to Claim 22, wherein the step (c2) includes adjusting a proportion of actual ink quantity of the spot color

ink included in the color separation ink quantity set for reproducing the reproduction color to a hypothetical ink quantity of the spot color ink decreases monotonically as the lightness parameter value changes in a lighter direction, the hypothetical ink quantity of the spot color ink being obtainable by adjusting ink quantity of each ink so as to minimize a sum of ink quantities.

30. A color separation method according to Claim 22, wherein the step (c2) includes adjusting the ink quantity of the spot color ink to be zero in a first range which is a highest lightness portion within an entire range of the lightness parameter value.

31. A color separation method according to Claim 22, wherein the lightness parameter value is a maximum ink quantity of the spot color ink when the spot color ink is used as much as possible within a range in which the reproduction color is reproducible.

32. A color separation method according to Claim 22, wherein the step (c2) includes the steps of:

(c2-1) determining a reference ink quantity of the spot color ink, depending on the reproduction color, according to a predetermined condition established in advance;

(c2-2) determining a reference ink quantity set, by determining a reference ink quantity for each ink of the ink set necessary for reproducing the reproduction color in combination with the reference ink quantity of the spot color ink;

(c2-3) determining a residual ink quantity parameter that relates to magnitude of a plurality of reference ink quantities excluding the reference ink quantity of the spot color ink from among the plurality of reference ink quantities included in the reference ink quantity set; and

(c2-4) determining an ink quantity of the spot color ink included in the color separation ink quantity set such that for substantially same lightness

parameter values, the usage rate of the spot color ink is smaller in association with a smaller value of the residual ink quantity parameter.

33. A color separation method according to Claim 32, wherein the spot color ink reference ink quantity is a maximum ink quantity of the spot color ink when the spot color ink is used as much as possible within a range in which the reproduction color is reproducible.

34. A color separation method according to Claim 32, wherein the residual ink quantity parameter value is a sum of values derived by multiplying the plurality of reference ink quantities excluding the reference ink quantity of the spot color ink by predetermined coefficients associated with each ink of the ink set.

35. A color separation method according to Claim 34, wherein each of the coefficients is set to greater values as reflection density of ink dot of a corresponding ink becomes denser.

36. A color separation method according to Claim 34, wherein each of the coefficients is set to greater values as apparent color difference between color of a corresponding ink and color of the spot color ink is smaller.

37. A color separation method according to Claim 32, wherein the step (c2-4) includes the steps of:

(c2-4-1) calculating a temporary ink quantity of the spot color ink based on the lightness parameter value and the residual ink quantity parameter value;

(c2-4-2) determining a temporary ink quantity set by determining temporary ink quantities for the chromatic primary color inks which in combination with the temporary ink quantity of the spot color ink are needed to reproduce the reproduction color; and

(c2-4-3) adopting the temporary ink quantity set as-is as the color separation ink quantity set when the temporary ink quantity set is within ink duty limits which limit an upper value of ink quantity useable per unit of area of the print medium, and when the temporary ink quantity set exceeds the ink duty limits, determining the color separation ink quantity set by correcting the temporary ink quantity set so as to meet the ink duty limits.

38. A color separation method according to Claim 37, wherein the ink set includes first and second spot color inks,

the step (c1) includes calculating the lightness parameter value independently for each of the first and second spot color inks,

the steps (c2-1), (c2-2) and (c2-3) each includes calculating the reference ink quantity set and the residual ink quantity parameter value independently for each of the first and second spot color inks,

the step (c2-4-1) includes determining the temporary ink quantity for each of the first and second spot color inks according to the reference ink quantity set and the residual ink quantity parameter value for each of the first and second spot color inks, and

in the step (c2-4-3), when the temporary ink quantity set exceeds the ink duty limits, the color separation ink quantity set is determined such that, in a two-dimensional color space defined by ink quantities of the first and second spot color inks, a color coordinate point defined by color separation ink quantities of the first and second spot color inks is present within the ink duty limits and situated in proximity to a color coordinate point defined by the temporary ink quantities of the first and second spot color inks.

39. A color separation method according to Claim 38, wherein

in the step (c2-4-3), when the temporary ink quantity set exceeds the ink duty limits, the color separation ink quantity set is determined such that, in the two-dimensional color space relating to ink quantities of the first and second spot color inks, the color coordinate point defined by color separation ink quantities of the first and second spot color inks is present within the ink

duty limits, and such that a ratio of the color separation ink quantities of the first and second spot color inks is equal to a ratio of the temporary ink quantities of the first and second spot color inks.

40. A color separation method according to Claim 22, wherein the step (b) comprises the steps of:

(b1) determining an outermost shell color separation ink quantity set associated with outermost shell chromatic color, where the outermost shell chromatic color refers to chromatic color at an outermost shell location within the primary color space, the outermost shell color separation ink quantity set being used for reproducing extended chromatic color that is reproducible with the ink set and that has higher saturation than the outermost shell chromatic color; and

(b2) determining the plurality of reproduction colors associated respectively with the plurality of input colors within the primary color space, based on relationship between the outermost shell chromatic color and the outermost shell color separation ink quantity set;

wherein the step (b1) includes the steps of:

establishing an upper limit of useable ink quantity per unit of area of the print medium as an ink duty limit; and

determining the extended chromatic color as a color represented by an extended chromatic color vector of greater length having a same direction as an outermost shell chromatic color vector representing the outermost shell chromatic color in the primary color space, and determining the outermost shell color separation ink quantity set for reproducing the extended chromatic color;

and wherein determination of the extended chromatic color and the outermost shell color separation ink quantity set is performed so as to meet the following condition:

(i) the outermost shell color separation ink quantity set is within the ink duty limit.

41. A color separation method according to Claim 40, wherein determination of the extended chromatic color and the outermost shell color separation ink quantity set is performed so as to additionally meet the following condition:

(ii) length of the extended chromatic color vector is the greatest length within a range reproducible by the ink set.

(ii) length of the extended chromatic color vector is the greatest length within the range reproducible by the ink set.

42. A color separation method according to Claim 40, wherein determination of the extended chromatic color and the outermost shell color separation ink quantity set is performed so as to additionally meet the following condition:

(iii) total ink quantity of the outermost shell color separation ink quantity set for reproducing the extended chromatic color is the smallest possible.

43. A color separation method according to Claim 40, wherein the reproduction color is a color reproduced by a provisional color separation ink quantity set derived by multiplying the outermost shell color separation ink quantity set for the outermost shell chromatic color having a same vector as the input color in the primary color space, by a ratio of a length of the input color vector to a length of the outermost shell chromatic color vector.

44. A color separation method according to Claim 22, wherein the spot color ink contains colorant different from colorants of the plurality of chromatic primary color inks.

45. A color separation method according to Claim 22, wherein the spot color ink is able to reproduce higher saturation than a mixture of the chromatic primary color inks when a hue reproducible by the spot color ink is reproduced by the mixture of the plurality of chromatic primary color inks.

46. A color separation method according to Claim 22, wherein the ink set includes two first and second spot color inks of mutually different hues,

wherein a term "substitution quantities" for a particular spot color ink denotes ink quantities of the plurality of chromatic primary color inks used for reproducing hue and saturation substantially identical to the particular spot color ink by means of substituting a particular quantity of the particular spot color ink with a combination of the plurality of chromatic primary color inks,

wherein a term "principal component primary color inks" for each of the first and second spot color inks denotes two inks with largest substitution quantities,

and wherein one of the two principal component primary color inks for the first spot color ink and one of the two principal component primary color inks for the second spot color ink are different inks.

47. A color separation method according to Claim 22, wherein the ink set includes black ink, and

the step (b) comprises the step of calculating a corrected input color composed of a plurality of chromatic primary color components which are decreased so as to produce a black component by means of an under color removal process for the black ink on the input color,

and wherein the reproduction color is determined according to the corrected input color.

48. A method for creating a color conversion lookup table for converting input color image data expressed in a first color system into second color image data expressed in a reproduction color system,

wherein the reproduction color system is a color system for reproducing color using an ink set that includes a plurality of chromatic primary color inks that used in combination can reproduce achromatic color,

and at least one spot color ink of hue different from any of the plurality of chromatic primary color inks;

wherein the method for creating a color conversion lookup table comprises the steps of:

establishing a first correspondence relationship for converting a first tone value set expressed in the first color system to a primary color tone value set expressed in a primary color system for ink quantities of the plurality of chromatic primary color inks;

establishing a second correspondence relationship for converting a primary color tone value set for each of a plurality of input colors within the primary color system into ink quantities of the ink set in accordance with the color separation method of Claim 22; and

calculating, based on the first and second correspondence relationships, correspondence relationships between the first tone value set expressed in the first color system and ink quantities of the ink set, and storing the relationships in the color conversion lookup table.

49. An image data processing apparatus for converting input color image data expressed in a first color system to second color image data expressed in a reproduction color system, the apparatus comprising:

a color conversion lookup table created according to the method of Claim 48; and

a color conversion module for executing the converting while making reference to the color conversion lookup table.